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**Musoll**

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(54) **METHOD AND APPARATUS FOR PREDICTING CHARACTERISTICS OF INCOMING DATA PACKETS TO ENABLE SPECULATIVE PROCESSING TO REDUCE PROCESSOR LATENCY**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,056,058 A * 10/1991 Hirata et al. ................ 709/230
5,260,942 A * 11/1993 Auerbach et al. ........... 370/474
5,557,608 A * 9/1996 Calvignac et al. ........... 370/389
5,857,201 A * 1/1999 Wright et al. ............ 707/104.1
6,243,610 B1 * 6/2001 Iino et al. ...................... 700/1
6,359,883 B1 * 3/2002 Lechleider .................. 370/389
6,430,156 B1 * 8/2002 Park et al. ................... 370/232
6,622,173 B1 * 9/2003 Luke ......................... 709/237

FOREIGN PATENT DOCUMENTS

WO WO0111834 A1 * 2/2001

OTHER PUBLICATIONS

Krishnamurthy, Balachander and Rexford, Jennifer, "En Passant: Predicting HTTP/1.1 Traffic," 1999, IEEE, vol. 3, pp. 1768-1773.*
Kim, Tae-eun et al., "Improving Congestion Control Performance Through Loss Differentiation," Oct. 1999, IEEE, pp. 412-418.*
Matic, Victor et al. "Predictive Playout Delay Adaptation for Voice over Internet," 2000, IEEE, pp. 348-351.*
Yuan, Chin and Silvester, John A. "Queueing Analysis of Delay Constrained Voice Traffic in a Packet Switching System," 1989, IEEE, vol. 7, No. 5, pp. 729-738.*
Enrique Musoll Prediction of Packet Flow, Packet Header and Packet Payload Jun. 14, 2001, Disclosure Document #495342, USPTO.

* cited by examiner

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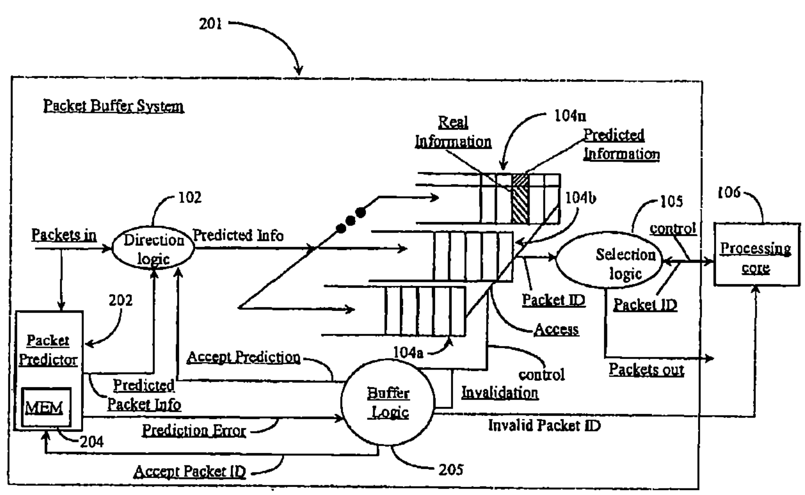
(57) **ABSTRACT**

A system for processing data packets in a data packet network has at least one input port for receiving data packets, at least one output port for sending out data packets, a processor for processing packet data, and a packet predictor for predicting a future packet based on a received packet, such that at least some processing for the predicted packet may be accomplished before the predicted packet actually arrives at the system. The system is used in preferred embodiments in Internet routers.

**22 Claims, 5 Drawing Sheets**



## DESCRIPTION OF THE PREFERRED EMBODIMENTS

As described in the background section of this specification, current art packet processors, operating typically in data routers, operate only on packets received to be routed. The inventor, according to an embodiment of the present invention, provides an apparatus and method that enables a processor to predict characteristics of a next incoming data packet and initiate speculative processing before the actual next packet arrives for processing. The method and apparatus of the present invention is described in enabling detail below.

FIG. 1 is block-diagram illustrating components of a typical network processing system according to prior-art. A packet buffer or queuing system **101** is illustrated in this example of prior art as a typical system present in data packet processors. Packet buffering system **101** comprises a direction logic block **102** adapted for receiving data packets at ingress and determining which of a plurality of data queues will be selected for holding the packet data prior to processing. In this example, there are a plurality of logically-illustrated queues **104***a*, **104***b* to **104***n*. It will be appreciated by one with skill in the art of data processors that there typically may be more than three queues associated with a data packet processor used for data routing on a data network.

In this example, an incoming data packet labeled Packet Info has been entered in queue **104***n* as indicated by cross-hatching. The data actually stored in such a queue can include simply packet identifiers and a packet header to be processed, or a complete and full data packet. This option is largely design dependant. The set of queues **104***a-n* has an associated buffer control logic **103** that is connected by control path to a common access path or line shared by each queue. The method of control and communication between buffer logic **103** and queue set **104***a-n* is only logically represented in this example. Actual physical links and structures may vary according to design. It will be appreciated by the skilled artisan that multiple ingress ports may share one set of data queues **104***a*-**104***n* and that it is assumed that data packets are serially enqueued and dequeued.

Selection logic **105** is illustrated within packet buffer system **101** and is adapted to manage how processed packets are selected to be sent out of queue to egress of the processing system after processing is complete. Selection logic **105** is illustrated as connected by control path to a common access line shared by all of the queues in set **104***a-n* as was described above with reference to direction logic **103**. A processing core **106** is illustrated in this embodiment and is adapted to process data packet information while data packets are in the system. Processing core **106** is logically connected through selection logic **105** to queue set **104***a-n* by a control line.

In typical prior-art processing, packets arrive through ingress of the system as illustrated herein by the label Packets In, and are buffered in any one of queues comprising set **104***a-n* according to direction logic **102**. At least a packet identifier including a queue address location identifier labeled herein simply Packet ID is made available to processing core **106**. Core **106** processes the packet information according to applicable software. It is noted in this prior-art example that processing by core **106** cannot begin until an actual data packets or sufficient information of one is enqueued in one of queues **104***a-n* and is identified and registered within the system.

It is known that data traffic over a data-packet-network such as the Internet network typically arrives at processors in a series of data bursts. This means that the processing workload over time of core **106** will experience peaks, valleys, and perhaps periods of idleness. These periods of low workload and idle times are unavoidable in the current art. The goal of the present invention is to utilize low workload and idle times for speculative data processing on future data packets yet to arrive.

FIG. 2 is a block-diagram illustrating components of a novel network processing system according to an embodiment of the present invention. In this example, a packet buffering system **201** is provided with a capability of predicting characteristics of some data packets before they arrive to the processing system. System **201** comprises queues **104***a-n* as described with reference to FIG. 1 above. Direction logic **102** and selection logic **105** are also present in this example as is processing core **106**, and these elements are analogous to the components with the same element numbers previously described.

A novel hardware mechanism labeled herein Packet Predictor **202** is provided within system **201** and enables prediction of data packet characteristics before some packets actually arrive through ingress of the processing system. Data packet predictor **202** is a front-end hardware implementation that generates speculative packet information for a virtual data packet (predicted data packet). A packet prediction may be triggered by any one of several events and conditions, such as detection of idle processor time. A good time, however, and a trigger used in a preferred embodiment is when a real data packet is received by the processing system.

Packet predictor **202** has, in this example, a dedicated memory (MEM) **204** provided therein and adapted to store historical data regarding real data packets previously processed within the system and historical data about successful instances of predicted data packets within the system, wherein the speculative processing results associated with a predicted packet, backed up by a real packet, were correct enough to send the real packet out of the system requiring little or no processing of the information associated with the real packet. MEM **204** can be a flash type MEM, ROM, RAM, or any other type of usable memory sufficient in size to hold at least a historical record covering a pre-defined number of data packets.

In a preferred embodiment, MEM **204** stores a revolving history record that is updated periodically, whether or not the processing was "real" or "virtual". For example, MEM **204** may store historical data covering the last 10 data packets received, and also the practical result of the last ten data packets predicted. In other embodiments the history record could cover many more, or fewer data packets, both real and virtual. In an alternative embodiment of the invention, MEM **204** may be implemented externally from predictor **202** or from buffer system **201**, or even externally from the router without departing from the spirit and scope of the present invention. For example, MEM **204** may be an assigned portion of existing memory within the processing system such as queue memory or processing core memory. There are many possibilities.

A buffer logic **205** is provided within packet buffering system **201** and adapted to control queue-state reporting and management of queues **104***a-n* similarly to buffer logic **103** described above with reference to FIG. 1. In this example logic **205** is enhanced to manage queue set **104***a-n* according to additional predictive capabilities of the present invention. Logically speaking, buffer logic **205** has control connection to a shared access line of queue set **104***a-n* as well as a control and communication connection to packet predictor **202**. Additionally, there are illustrated connections between buffer logic **205** and direction logic **102** and between buffer logic

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(12) **United States Patent**
**Rees**

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(54) **VOICE ACTIVATED DEVICE**

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*G10L 15/00* (2006.01)

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(58) **Field of Classification Search** ................. 704/270, 704/275, 233, 214, 217
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 4,951,079 | A | 8/1990 | Hoshino et al. | |
| 5,027,149 | A * | 6/1991 | Hoshino et al. | 396/56 |
| 5,983,186 | A * | 11/1999 | Miyazawa et al. | 704/275 |
| 6,049,766 | A | 4/2000 | Laroche | |
| 6,272,460 | B1 * | 8/2001 | Wu et al. | 704/226 |
| 6,711,536 | B2 | 3/2004 | Rees | |
| 2003/0154078 | A1 | 8/2003 | Rees | |
| 2003/0163313 | A1 | 8/2003 | Rees | |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| EP | 1 187 099 | 3/2002 |
| JP | 60-205432 | 10/1985 |
| JP | 60-205433 | 10/1985 |
| JP | 2000-227633 | 8/2000 |
| JP | 2001-305642 | 11/2001 |
| JP | 2002-354335 | 12/2002 |

OTHER PUBLICATIONS

R.Tucker□□"Voice activity detection using a periodicity measure"□□IEEE, Aug. 1992, pp. 377-380.*

* cited by examiner

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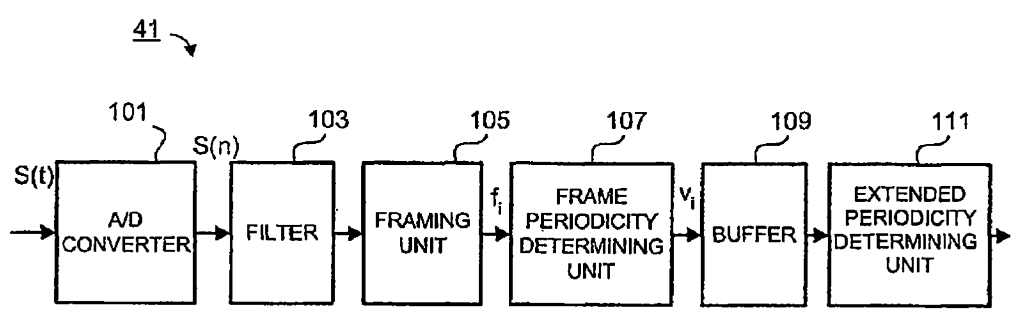
(57) **ABSTRACT**

A voice activated camera is described which allows users to take remote photographs by speaking one or more keywords. In a preferred embodiment, a speech processing unit is provided which is arranged to detect extended periodic signals from a microphone of the camera. A control unit is also provided to control the taking of a photograph when such an extended periodic component is detected by the speech processing unit.

**15 Claims, 6 Drawing Sheets**



shown in FIG. 2, the camera 3 also includes a microphone 39 for converting a user's speech into corresponding electrical speech signals; and a speech processing unit 41 which processes the electrical speech signals to detect the presence of a keyword in the user's speech and which informs the camera control unit 33 accordingly.

Speech Processsing Unit

As discussed above, the speech processing unit 41 is arranged to detect keywords spoken by the user in order to control the taking of remote photographs. In this embodiment, the speech processing unit does not employ a "conventional" automatic speech recognition type keyword spotter which compares the spoken speech with stored models to identify the presence of one of the keywords. Instead, the speech processing unit 41 used in this embodiment is arranged to detect a sustained periodic signal within the input speech, such as would occur if the user says the word "cheeeese" or some other similar word. The inventor has found that because of the strong periodic nature of such a sustained vowel sound, the speech processing unit 41 can still detect the sound even at very low signal-to-noise ratios.

The way in which the speech processing unit 41 operates in this embodiment will now be explained with reference to FIGS. 3 to 7.

FIG. 3 illustrates the main functional blocks of the speech processing unit 41 used in this embodiment. The input signal (S(t)) received from the microphone 39 is sampled (at a rate of just over 11 KHz) and digitised by an analogue-to-digital (A/D) converter 101. Although not shown, the speech processing unit 41 will also include an anti-aliasing filter before the A/D converter 101, to prevent aliasing effects occurring due to the sampling. The sampled signal is then filtered by a bandpass filter 103 which removes unwanted frequency components. Since voiced sounds (as opposed to fricative sounds) are generated by the vibration of the user's vocal cords, the smallest fundamental frequency (pitch) of the periodic signal to be detected will be approximately 100 Hertz Therefore, in this embodiment, the bandpass filter 103 is arranged to remove frequency components below 100 Hertz which will not contribute to the desired periodic signal. Also, the bandpass filter 103 is arranged to remove frequencies above 500 Hertz which reduces broadband noise from the signal and therefore improves the signal-to-noise ratio. The input speech is then divided into non-overlapping equal length frames of speech samples by a framing unit 105. In particular, in this embodiment the framing unit 105 extracts a frame of speech samples every 23 milliseconds. With the sampling rate used in this embodiment, this results in each frame having 256 speech samples. FIG. 4 illustrates the sampled speech signal (S(n), shown as a continuous signal for ease of illustration) and the way that the speech signal is divided into non-overlapping frames.

As shown in FIG. 3, each frame $f_1$ of speech samples is then processed by a frame periodicity determining unit 107 which processes the speech samples within the frame to calculate a measure ($v_i$) of the degree of periodicity of the speech within the frame. A high degree of periodicity within a frame is indicative of a voiced sound when the vocal cords are vibrating. A low degree of periodicity is indicative of noise or fricative sounds. The calculated periodicity measure ($v_i$) is then stored in a first-in-first-out buffer 109. In this embodiment, the buffer 109 can store frame periodicity measures for forty-four consecutive frames, corresponding to just over one second of speech. Each time a new frame periodicity measure is added to the buffer 109, an extended periodicity determining unit 111 processes all of the forty-four periodicity measures in the buffer 109 to determine whether or not a sustained periodic sound is present within the detection window represented by the forty-four frames.

When the extended periodicity determining unit 111 detects a sustained periodic sound within the speech signal, it passes a signal to the camera control unit 33 confirming the detection. As discussed above, the camera control unit 33 then controls the operation of the camera 3 to take the photograph at the appropriate time.

Frame Periodicity Determining Unit

As those skilled in the art will appreciate, various techniques can be used to determine a measure of the periodicity of the speech within each speech frame. However, the main components of the particular frame periodicity determining unit 107 used in this embodiment is shown in FIG. 5. As shown, the frame periodicity determining unit 107 includes an auto-correlation determining unit 1071 which receives the current speech frame $f_i$ from the framing unit 105 and which determines the auto-correlation of the speech samples within the frame. In particular, the auto-correlation determining unit 1071 calculates the following function:

$$A(L) = \frac{1}{N-L} \sum_{j=0}^{N-L-1} x(j)x(j+L) \quad (1)$$

where x(j) is the $j^{th}$ sample within the current frame, N is the number of samples in the frame, j=0 to N−1 and L=0 to N−1.

The value of A(L) for L=0 is equal to the signal energy and for L>0 it corresponds to shifting the signal by L samples and correlating it with the original signal. A periodic signal shows strong peaks in the auto-correlation function for values of L that are multiples of the pitch period. In contrast, non-periodic signals do not have strong peaks.

FIG. 6 shows the auto-correlation function ($A_i(L)$) for a frame of speech $f_i$ representing a speech signal which is periodic and which repeats approximately every 90 samples. As shown in FIG. 6, the auto-correlation around L=180. Further, the value of the auto-correlation function at L=90 is approximately the same as the value at L=0, indicating that the signal is strongly periodic.

The fundamental frequency or pitch of voiced speech signals varies between 100 and 300 Hertz. Therefore, a peak in the auto-correlation function is expected between $L_{low}=F_s/300$ and $L_{high}=F_s/100$, where $F_s$ is the sampling frequency of the input speech signal. Consequently, in this embodiment, the auto-correlation function output by the auto-correlation determining unit 1071 is input to a peak determining unit 1073 which processes the auto-correlation values between $A(L_{LOW})$ and $A(L_{HIGH})$ to identify the peak value ($A(L_{MAX})$) within this range. In this embodiment, with a sampling rate of just over 11 kHz the value of $L_{LOW}$ is 37 and the value of $L_{HIGH}$ is 111. This search range of the peak determining unit 1073 is illustrated in FIG. 6 by the vertical dashed lines, which also shows the peak occurring at $L_{MAX}$=90. The auto-correlation values A(0) and $A(L_{MAX})$ are then passed from the peak determining unit 1073 to a periodicity measuring unit 1075 which is arranged to generate a normalised frame periodicity measure for the current frame ($f_i$) by calculating:

$$v_i = \frac{A_i(L_{MAX})}{A_i(0)} \quad (2)$$

where $v_i$ will be approximately one for a periodic signal and close to zero for a non-periodic signal.